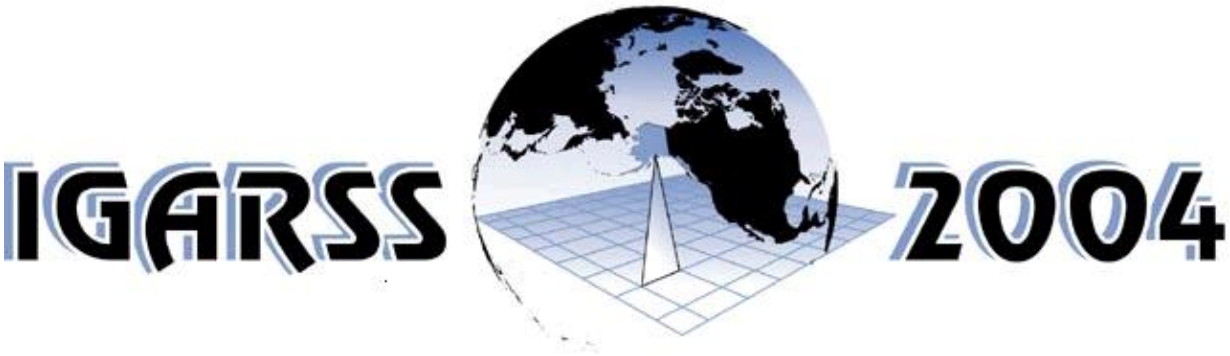

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Analysis of Summer 2002 Melt Extent on the Greenland Ice Sheet using MODIS and SSM/I Data

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***Abstract*-Previous work has shown that the summer of 2002 had the greatest area of snow melt extent on the Greenland ice sheet ever recorded using passive-microwave data. In this paper, we compare the 0° isotherm derived from the Moderate-Resolution Imaging Spectroradiometer (MODIS) instrument, with Special Sensor Microwave/Imager (SSM/I)-derived melt, at the time of the maximum melt extent in 2002. To validate the MODIS-derived land-surface temperatures (LSTs), we compared the MODIS LSTs with air temperatures from nine stations (using 11 different data points) and found that they agreed to within 2.3 ±2.09°C, with station temperatures consistently lower than the MODIS LSTs. According to the MODIS LST, the maximum surface melt extended to ~2300 m in southern Greenland; while the SSM/I measurements showed that the maximum melt extended to nearly 2700 m in southeastern Greenland. The MODIS and SSM/I data are complementary in providing detailed information about the progression of surface and near-surface melt on the Greenland ice sheet.**

I. INTRODUCTION

Previous work using data from the Special Sensor Microwave/Imager (SSM/I) has shown that the summer of 2002 had the greatest melt extent ever recorded using passive-microwave data [1], [2], [3]. If the Greenland ice sheet were to melt completely, as has happened in the past [4], it would contribute ~6.5 m of water to sea level [5], thus analysis of snow-melt patterns and trends on the Greenland ice sheet are of great importance. Moreover, surface melt can act to enhance the flow of outlet glaciers through crevasse overdeepening and contribute to the very rapid thinning of outlet glaciers [6]. In this paper, we explore the relationship between the Moderate-Resolution Imaging Spectroradiometer (MODIS)-derived 0°C isotherm and SSM/I-derived maximum melt zones for the period 26 July – 1 August 2002.

IV. RESULTS AND DISCUSSION

We found good correspondence between the MOD11 0°C isotherm and the upper boundary of the maximum melt from SSM/I in northern and southern Greenland and parts of southwestern Greenland (Figure 2). However, in most of the eastern and western parts of the ice sheet, and other parts of northern Greenland, the MOD11 0°C isotherm is at a lower elevation than is the SSM/I-derived maximum melt (Table 1) by up to ~900 m. Elevations were determined from the digital-elevation map of Bamber et al. [16].

The melt detected by the SSM/I sensor extends below the surface so that the MODIS- and SSM/I-derived melt extent should not necessarily be the same because the MOD11 product depicts the surface temperature of the ice only. And Figure 2 clearly shows that the MODIS- and SSM/I-derived snow-melt areas are generally not the same.

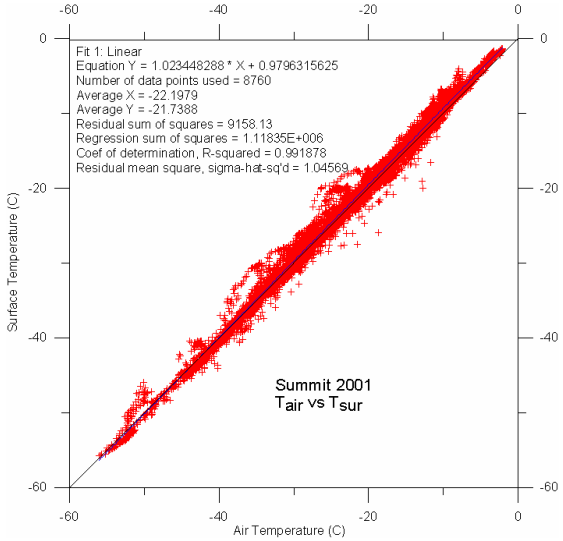

Figure 1. Hourly air temperatures versus surface temperatures in 2001 for Summit Station, Greenland. The "residual mean square" represents the average offset between the 2-m air and surface temperatures.

Table I
ELEVATION OF MODIS-DERIVED MAXIMUM SURFACE TEMPERATURE FROM THE MOD11 [15] PRODUCT, AND FROM SSM/I FOR THE DATES 26 JULY TO 1 AUGUST 2002. BLACK DOTS ON FIGURE 2 CORRESPOND TO LOCATION INFORMATION IN THIS TABLE.

Location on the Greenland ice sheet	Maximum elevation of melt from MOD11	Maximum elevation of melt from SSM/I
Northern Greenland	588 m	1484 m
Northeastern Greenland	1247 m	1856 m
Southeastern Greenland	2214 m	2693 m
Southern Greenland	2321 m	2321 m
Southwestern Greenland	1306 m	1946 m
Northwestern Greenland	832 m	1597 m

The passive microwave melt algorithm, the XGPR, uses 37 and 19 GHz channels and has a nominal spatial resolution of about 50 km. The XGPR is quite conservative in detecting melt, because the two frequencies have different penetration depths. (Using *only* the 37 GHz channel for melt detection provides larger melt areas.) The SSM/I is very sensitive to the amount of free water in the snow overlying glacier ice (less than 1 % of free water per volume), is not affected by cloud cover over Greenland, but has relatively poor resolution.